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Eastern Rivers and Mountains Network

Paleontological Resource Inventory and Monitoring
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On the Cover:
A *Neuropteris pocahontas* specimen from the Pocahontas Formation of West Virginia. *Neuropteris pocahontas* is abundant in this formation and is represented by fronds, pinnules, male reproductive bodies, and seeds. This plant species is used as a marker fossil to help paleontologists delineate the bottom section of the Pennsylvanian system. New River Gorge National River deposits contain these fossil remains. Additional fossil plant material has been recorded from multiple parks within the Eastern Rivers and Mountains Network.

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Introduction

Paleontological resources are the remains of past life preserved in a geologic context. These fossils are non-renewable resources that possess scientific and educational values.

Establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within National Park Service areas. Although over 160 National Park Service areas have been identified with paleontological resources, only a small percentage of these parks have adequate baseline paleontological resource data.

In conjunction with the National Park Service Geologic Resources Division and Inventory and Monitoring Networks, comprehensive paleontological resource inventories have been initiated in dozens of parks servicewide. This report represents paleontological resource inventory and monitoring data compiled for the parks within the Eastern Rivers and Mountains Network.

The Eastern Rivers and Mountains Network is comprised of 9 National Park Service areas: Allegheny Portage Railroad National Historic Site, Bluestone National Scenic River, Delaware Water Gap National Recreation Area, Fort Necessity National Battlefield, Friendship Hill National Historic Site, Gauley River National Recreation Area, Johnstown Flood National Memorial, New River Gorge National River, and Upper Delaware Scenic and Recreational River. These parks are located in New Jersey, New York, Pennsylvania, and West Virginia. The Eastern Rivers and Mountains Network preserves unique river and significant mountain forest resources.

Fossiliferous geologic units range from the Middle and Upper Ordovician (around 450 million years ago) to the Quaternary. Significant fossils of invertebrates, vertebrates, plants, and traces have been found in many of the parks, and the potential to discover new localities and specimens is great.

In particular, existing documentation on paleontological resources within Delaware Water Gap National Recreation Area and New River Gorge National River illustrate the significance and richness of fossils preserved by the Eastern Rivers and Mountains Network.

The variety, abundance, and continuing great potential for fossils in the Eastern Rivers and Mountains Network warrant the inclusion of these parks into the growing list of paleontological resource gems within the National Park Service.

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METHODS AND INVENTORY STRATEGIES

In order to better document fossil occurrences and to provide baseline paleontological resource data in National Park Service areas, the NPS Geologic Resources Division (GRD) and the NPS Inventory and Monitoring Program (I&M) have established three paleontological resource inventory strategies. These strategies include: comprehensive park-specific paleontological resource inventories, service-wide thematic paleontological resource inventories, and Inventory & Monitoring Network based baseline paleontological resource inventories, each established with their own goals and objectives. An article outlining basic paleontological resource monitoring strategies and potential threats to fossil resources is presented by Santucci and Koch (2003).

Comprehensive park inventories are designed to identify all known paleontological resources within a single park unit. Comprehensive park inventories involve the assembly of a team of specialists from within the NPS and from educational institutions and cooperators. These specialists work together with the park to identify and address all aspects of the paleontological resources within the targeted park, including resource management, museum curation, law enforcement, and interpretation. The goals and objectives of a park-specific paleontological resource inventory are detailed by Santucci (2000). An important component of many comprehensive paleontological inventories is to provide paleontology-specific training for park staff. Such park-specific comprehensive paleontological resource inventories have been completed at Yellowstone NP (first park to complete inventory), Arches NP, Bighorn Canyon NRA, Death Valley NP, Grand Teton NP, Santa Monica NRA, Walnut Canyon NM, and Zion NP.

Service-wide thematic paleontological resource inventories are designed to compile data regarding specific types of paleontological resources which occur in parks throughout the NPS. The first thematic paleontological resource inventory accomplished was an inventory of fossil vertebrate tracks from NPS areas (Santucci et al. 1998). Through this thematic inventory, a total of nineteen NPS units were identified as preserving fossil vertebrate tracks. Subsequent discoveries have increased the number of parks identified with fossil vertebrate tracks to twenty-five. Another example of a thematic paleontological resource inventory is the inventory of paleontological resources associated with NPS caves (Santucci et al. 2001). Fossils occur in two contexts relative to caves. First, fossils can be preserved in the marine limestones in which caves develop. Second, the remains of Ice Age animals and plants that lived, died or were transported into caves after death, are common types of cave fossils. The NPS Cave Paleontological Resource study initially identified thirty-five parks with cave fossils.

The third paleontological resource inventory strategy is the Inventory & Monitoring Network-based inventory strategy. Network-based paleontological resource inventories are designed to compile baseline paleontological resource data for each of the parks assigned to a particular network. Network-based inventories have been completed for one-third of the 32 I&M Networks including: the Eastern Rivers and Mountains, Greater Yellowstone, Mediterranean Coast, Mojave Desert, National Capital Region, Northeast Coastal and Barrier, Northern Colorado Plateau, Rocky Mountain, Southern Plains, and Southwestern Alaska networks. A similar paleontological inventory underway for the Upper Columbia Basin Network is scheduled for completion during FY2005.

The Network-based paleontological inventories are funded directly by the individual networks. Funds are used to provide stipends or salary for contractors, interns, or paleontological technicians who perform data mining activities. A brief summary outlining the basic techniques used to put together an I&M Network-based inventory is presented below.

The most valuable component of any paleontological resource inventory is an intensive literature search. Various databases contain citations for geology or paleontology themed publications. GeoRef, established by the American Geological Institute, is the primary database for geology references and contains millions of references from the mid 1700 s through today. GeoRef, available in both online or CD-ROM versions, is accessible at many major university libraries. The NPS NatureBib (which supercedes PaleoBib) is an internet based database for scientific citations presented as bibliographic references. NatureBib is a work in progress and does not yet contain a comprehensive paleontology bibliography. The USGS Library in Reston, Virginia is a premier repository for geologic publications, and houses most of the publications obtained for the network- based paleontological resource inventories. Additionally, museum libraries such as the Smithsonian Institution s National Museum of Natural History, and university libraries provide access to a wide range of geological and paleontological publications. Individual state geological surveys are also excellent sources of information and geologists familiar with local geology and paleontology.

The literature search also includes gray (unpublished) literature, searches of individual park files, museum archives, local newspapers, etc. These are often excellent sources of anecdotal information about park resources. In addition to literature searches, interviews with park staff, university faculty, geologists from the USGS and state surveys, and even local amateur geologists or paleontologists can yield information regarding park paleontological resources. These interviews frequently result in capturing data that may otherwise be undocumented and potentially lost or unrecognized.

As part of the bibliographic searches, a search for geologic maps associated with each park is undertaken. Tim Connors, a geologist with the NPS Geologic Resources Division, maintains a database of geological map coverage for many parks in the NPS. In addition, the USGS National Geologic Map Database (NGMDB; see citation below in References section) lists maps for a given geographic area or place name. The NGMDB also provides information on where to obtain maps. Geologic maps show the type of rocks and the associated geological formations present within a park area. These maps, alone, will often indicate the potential for paleontological resources to occur within a park. Fossils, with only rare exceptions, are found in sedimentary rocks such as sandstones, shales, and limestones. Fossils, with few exceptions, are not found within igneous rocks (volcanic, or of molten origin) or metamorphic rocks (mechanically and chemically altered) due to the extreme heat and/or pressure associated with the origin and history of these rocks types. The nomenclature for geologic formations can be confusing. The NGMDB also includes a searchable lexicon of valid geologic formation names. This lexicon provides a basic summary for each formation and summarizes current and past usage of the various formation names found in the literature. It also provides an annotated bibliography for each formation. The lexicon is very useful in cleaning up nomenclatural confusion.

The information from all these various sources for each park is then compiled and summarized in a written report and developed into individual datasets. The reports undergo peer review by professional geologists, paleontologists, and staff from each park, for accuracy before being submitted to the network. This report is designed to consolidate baseline paleontological resource data for each park to support management operations and decision- making. Therefore, the reports are written in NPS language and in additional to the scientific information, the reports address issues of resource management, protection, and interpretation.

The paleontological resource inventory reports synthesize information regarding the scope and significance of fossils documented from each park. Fossils are assessed and organized based upon taxonomy, stratigraphy, and paleoecology. Taxonomically, paleontological resources can be divided into four groups: paleobotany (fossil plants), invertebrates (animals without backbones), vertebrates (animals with backbones), and trace fossils (evidence of biological activity such as track, trace, burrow, etc.). Stratigraphically, fossils typically have a finite span and occurrence in geologic time (a geologic time scale is included in Appendix A). The period between the first occurrence and final occurrence of a fossil species is referred to as the stratigraphic range zone. Thus specific groups of fossils may be identified directly with a particular stratigraphic unit or stratigraphic range. Likewise, rock units often represent specific ancient sedimentary depositional environments. Paleoecologically, fossil groups may occur primarily, or in some instances only, in specific environmental conditions (temperature, aquatic, terrestrial, etc.). Thus many fossils may be useful as indicators of past environmental conditions. The reports are organized stratigraphically presenting the geologic and paleontologic information chronologically from oldest to youngest. Important fossils documented from localities outside a park are often reported in the park inventory, as this data may indicate the potential for fossils in similar stratigraphic units exposed in park boundaries.

Given the tremendous diversity of past life, the existence of life for over a billion years, and the range of environments that life has adapted, there is a broad spectrum of research interests in paleontology. It is not surprising that most of what is to be learned about the history of life remains to be discovered. Through research, over 170 NPS areas have been identified as containing paleontological resources. However, the paleontological research for a particular park may vary widely from an incidental fossil discovery to over a century of intensive paleontological investigations. The inventory reports include information on the history of paleontological research, descriptions of current cooperative projects, identification of any museum or universities serving as repositories for park fossils, and a comprehensive list of publications related to paleontological research associated with the park. Organizationally, the reports include any and all bibliographies that may be associated to a park s paleontological resources. However, bibliographic data are subdivided in the report into those cited in the narrative (References Cited) and other associated bibliographies (Additional References). The cooperative projects section highlights projects, if any, that the park has funded or supported relating to paleontological resources. Formal datasets are established for known associated paleontological collections, research, or activities.

Our knowledge of the fossil record is only a good as our previous field season. The potential for new paleontological discoveries is proportionally related to our understanding as managers and stewards of this non- renewable evidence of life from the past. We believe that the baseline information provided in these reports and the resulting increased understanding of paleontological resources will inevitably result in paving the way for future fossil discoveries in NPS areas.

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NPS Eastern Rivers and Mountains Network: http://www1.nature.nps.gov/im/units/ermn/

NPS Geologic Resources Division: http://www2.nature.nps.gov/geology/

NPS Paleontology Program: http://www2.nature.nps.gov/geology/paleontology/

NPS Park Paleontology Newsletter: http://www2.nature.nps.gov/geology/paleontology/news/newsletter.htm

Pennsylvania Geological Survey: http://www.dcnr.state.pa.us/topogeo/

Smithsonian National Museum of Natural History Dept. of Paleobiology: http://www.nmnh.si.edu/paleo//

Topozone (access to all U.S. topographic maps): http://www.topozone.com

U.S. Geological Survey: http://www.usgs.gov

U.S. Geological Survey National Geologic Map Database (NGMDB): http://ngmdb.usgs.gov/

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West Virginia Geological and Economic Survey: http://www.wvgs.wvnet.edu/

ALLEGHENY PORTAGE RAILROAD NATIONAL HISTORIC SITE

Allegheny Portage Railroad National Historic Site (ALPO) was originally established in 1964. This site preserves traces of the first railroad crossing of the Allegheny Mountains. The inclined plane railroad was built between 1831 and 1834, and subsequently abandoned no later than 1857.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

Fossils have been recorded from the Pottsville Formation and/or Allegheny Formation within the boundaries of ALPO. Park managers know the exact locations of these recorded fossils. Other formations found within the park are known to contain paleontological resources, although no reported discoveries have occurred within ALPO.

ALPO preserves two separate administrative areas in Blair County, Pennsylvania. The eastern area contains the visitor center, Lemon House, Engine House 6 Exhibit Building, and Skew Arch Bridge. The geologic formations preserved in this eastern area (range from Devonian to Pennsylvanian) and include: Brallier, Harrell, Scherr, Foreknobs, Catskill, Rockwell, Burgoon, Mauch Chunk, Pottsville, Allegheny, and Glenshaw formations. The western area preserves the Staple Bend Tunnel, which contains the Allegheny, Pottsville, and Mauch Chunk formations.

The Harrell and Brallier formations are Upper Devonian in age and are composed of siltstone, shale, and black shale. The lower half of the Harrell Formation contains styliolinids, lingulid brachiopods, and conodonts (Harper, 1999). Palynomorph assemblages of both of these formations from Pennsylvania were studied by Norton and Allen (1970). Many of the forms represent a distinct flora similar to those described in Europe. Rossbach (2000) investigated migration and endemism of fossil invertebrates, including conularids from the Brallier Formation. Rossbach concluded close evolutionary ties with European fauna.

The Upper Devonian Scherr Formation is primarily composed of siltstone, sandstone, shale, and mudstone. Berg and others (1980) report that the Scherr Formation contains marine fossils.

The Foreknobs Formation is found stratigraphically above the Scherr Formation and is also Upper Devonian in age. This formation is composed of sandstone, siltstone, shale, and conglomerate. Dennison (1970) reports scattered marine fossils in the shale beds of the Foreknobs Formation. Rutledge and others (2002) identified two distinct fossil assemblages in the Foreknobs Formation that are characterized by the presence or absence of brachiopods and pelecypods. Berg and others (1980) also report some marine fossils from this formation.

The Devonian Catskill Formation consists of sandstone, siltstone, shale, conglomerate, and mudstone. This formation contains both marine and nonmarine fossils (Berg et al., 1980; Harper, 1999). The Academy of Natural Sciences in Philadelphia is currently working on what they refer to as the Catskill Project . This research led to the discovery of plants, plant spores, invertebrates, and all major classes of vertebrates. Additionally, they have discovered and described two new taxa of limbed (tetrapod) vertebrates from the Catskill Formation; *Densignathus rowei* and *Hynerpeton bassetti*. These significant tetrapod discoveries from Clinton County, Pennsylvania have extended the temporal range of North American tetrapods and shed light on morphological evolution (Daeschler et al., 1994). Additionally, the State Museum of Pennsylvania houses many fish specimens and the University of California Museum at Berkeley houses 1 plant and 4 vertebrate specimens from the Catskill Formation. Specific paleobotanical research was conducted by Scheckler and Banks (1971) and Brauer (1980). Scheckler and Banks investigated a new genus of progymnosperms and suggest some evolutionary trends among the Aneurophytales. Brauer discusses interesting features of a *Barinophton citrulliforme* and suggests various interpretations. Fossil pollen analyses were conducted from Catskill Formation material in order to help date rocks and differentiate sedimentary units (Traverse, 1974; Wilson and Traverse, 1975). Lastly, Walter (2001) researched evidence for the earliest known wildfire from a charcoal deposit in the Catskill Formation.

The Rockwell Formation was deposited during the Devonian- Mississippian transition. This geologic unit is composed of argillaceous (composed of clay minerals) sandstone, shale, carbonaceous (rich in carbon) shale, conglomerate, and diamictite (massive, structureless rock). Palynological studies of fossil spores from the Rockwell Formation were conducted by Wood (1987). Brownish- gray to grayish- black shale beds are known to contain marine fossils; in particular, the unit called the Riddlesburg Shale. (Berg, 1999; Reger, 1927). Dennison and others (1986) report brackish- water fauna and green- gray S*kolithos* burrowed (worm tube burrowed) sandstones from the Rockwell Formation.

The Mississippian Burgoon Sandstone is primarily a non- marine, fluvial sandstone (T. Kammer, written communication, 2004). This formation also consists of conglomerate, shale, and coal. Trace fossils have been discovered in this formation in central- western Pennsylvania and plant fossils are noted from northern, western, and central Pennsylvania (Berg et al., 1980).

The Mauch Chunk Formation is also Mississippian in age and is composed of shale, siltstone, sandstone, conglomerate, and limestone. Brezinski (1984) describes a bioturbated (churned sediments by an organism) mudstone that was deposited in a shoal environment in a shallow lagoon from the Mauch Chunk Formation. Fossil plants in the Mauch Chunk Formation have been studied, with a particular emphasis on the morphology of *Adiantites antiquus* (Jennings, 1985) and on new interpretations of *Lepidocarpon* (Miklausen, 1989). Hoque (1968) investigated fish fragments and worm burrows and Edmunds and others (1979) researched invertebrate body fossils from the Mauch Chunk Formation. Two trilobite species from the genus *Paladin* were discovered in the Mauch Chunk Formation (Brezinski, 1988). These fossils were primarily found in nearshore shaly environments within bivalve- dominated communities. Most notably, the Thompson Quarry located near Chalk Hill, Pennsylvania, has produced abundant and diverse marine fossils from the Mauch Chunk Formation. Researchers have identified corals, conulariids, bryozoans, brachiopods, gastropods, pelecypods, cephalopods, trilobites, blastoids, and crinoids (Simonsen, 1988). Additionally, the same research team discovered microfossils of foraminifera, conodonts, and ostracodes. Rollins and Brezinski (1988) also studied the Thompson Quarry site and reported on bryozoans, brachiopods, bivalves, trilobites, and crinoids.

The Pottsville Formation is Pennsylvanian in age and has a wide compositional range including; sandstone, conglomerate, shale, siltstone, claystone, limestone, and coal. Edmunds and others (1999) report that the shales periodically contain marine and brackish- water fauna in western Pennsylvania. Also, marine invertebrates and plant fossils from the Pottsville Formation were researched by Edmunds (1992), which aided in defining age determinations for the formation. In northeastern Pennsylvania, preservation of fossil plants from the Pottsville Formation were studied by Grandstaff (1977) and fossil insects were researched by Carpenter (1960, 1967). In western Pennsylvania, macrofauna investigations were conducted by Williams (1960, 1980) and microfauna explorations of fusulinids and conodonts have been recorded (Smyth, 1974; Merrill, 1970- 1971).

The Allegheny Formation overlies the Pottsville Formation and is also Pennsylvanian in age. The Allegheny Formation consists of sandstone, shale, limestone, clay, and coal. Microfossils including conodonts and two species of the fusulinid *Beedeina* were studied from the Allegheny Formation (Rice et al., 1994). Twenty- five species of gastropods were studied by Sturgeon (1945) from the Allegheny Formation of eastern Ohio. In western Pennsylvania, macrofauna investigations were conducted by Williams (1960, 1980) and microfauna explorations of fusulinids and conodonts have been recorded (Smyth, 1974; Merrill, 1970- 1971). Smith (1968) studied macrofauna of the Allegheny Formation. Specific research was conducted on the Allegheny Formation cephalopods (Sturgeon, 1964; Murphy, 1966) and vertebrates (Lund,1975).

The youngest unit in ALPO is the Glenshaw Formation, which is composed of shale, sandstone, limestone, and coal. The Glenshaw Formation is known to be very fossiliferous in many areas of Pennsylvania, Ohio, and West Virginia, most notably in the Brush Creek, Pine Creek, and Ames marine zones. In southwestern Pennsylvania, Roen and others (1968) report that the limestone and calcareous shale contain marine fossils. Biogenic mounds containing abundant vertical burrows, presumably from malacostracan crustaceans, are known from southwestern Pennsylvania and eastern Ohio exposures of the Glenshaw Formation (Carothers and Norton, 1975). Crinoid and trilobite fossils from the Glenshaw Formation were used for investigations of mineralogy and fluorescence of skeletal carbonates by Durika and others (1987). Foraminifera have also been studied from the Glenshaw Formation. Palaeotextulariid foraminifera and endothyroid foraminifera were reported on from the Appalachian basin (Moira et al., 1988; Hoare and Sturgeon, 1998). From a quarry in eastern Ohio, Rollins and others (1979) report are variety of fauna from the Glenshaw Formation including, fusulinids, bryozoans, brachiopods, crinoids, and fish fragments. Lepold (2003) reports corals, brachiopods, bivalves, and crinoids from the Glenshaw Formation in eastern Ohio. Conodonts were examined at Ebensburg, Pennsylvania to identify the marine unit as part of the Ames (Merrill, 1988). Additional fauna at the site include foraminifera, brachiopods, bivalves, gastropods, cephalopods, echinoderms, and shark s teeth (Brady et al., 1985). An additional locality in Beaver County of the Ames marine zone produced over 30 species of invertebrates, vertebrates, and trace fossils (Harper, 1986). Conodonts from the Ames and Brush Creek marine zones were used for testing the validity of using uranium, thorium, and lead contents for dating (Kovach and Zartman, 1981).

Although these specimens were collected outside the boundaries of ALPO, historically important fossil discoveries were made along the Allegheny Portage Railroad from a number of formations and localities. Harper (2002) outlines the significance and historical events of fossil collecting and geologic mapping in the 1800s. In the 1830s Edward Miller investigated the geology and paleontology of the Portage Railroad route and made several collections along the way. Miller (1835) discovered plant fossils in what is probably the upper Rockwell Formation or Burgoon Sandstone. Harlan (1835) was the first to describe the plant specimens that Miller collected from the Portage Railroad (*Pecopteris obsolete*, *Pecopteris milleri*, and *Neuropteris* sp.). Conrad (1835) published a subsequent paper on research based from Miller s specimens. New species from this work included the marine gastropods *Stylifer primogenia*, *Turbo tabulatus*, *Turbo insectus*, the brachiopod *Productus confragosus* and the bivalve *Pecten armigerus*. Although Conrad s type specimens are lost, these species are known to occur in the Allegheny and Conemaugh groups, including the Glenshaw Formation in particular (Harper, 2002). Conrad s 1835 report is historically significant because it is the first published report of invertebrate fossils from the Coal Measures (Pennsylvanian) of North America (Harper, 2002). Additionally, Leidy (1856) describes a new shark tooth, *Petalodus allegheniensis*, from specimens found near the Bens Creek Station within the Glenshaw Formation.

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DATA SETS:

DS- ALPO-XXX	Allegheny Portage Railroad National Historic Site Paleontological Archives. 5/1985 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.
DS- ALPO-XXX	Allegheny Portage Railroad National Historic Site Files, Archive, Museum Records. 8/1964 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Allegheny Portage Railroad National Historic Site; status: Active.

BLUESTONE NATIONAL SCENIC RIVER

Bluestone National Scenic River (BLUE) was originally established in 1988 to preserve natural and historic features of the Appalachian Plateau within an 11- mile stretch of the lower Bluestone River.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The majority of BLUE is placed within the Upper Mississippian Hinton Formation. The perimeter of the park boundary also crosses into small sections of the Bluestone and Princeton formations. Additionally, Quaternary alluvium can be found in a limb that extends into the northeastern section of the park.

The oldest geologic formation within BLUE is the Upper Mississippian Hinton Formation. This formation is composed of sandstone, shale, siltstone, limestone, and coal and represents the interrelationship of marine and terrestrial sediments. Englund and others (1979a) report that plant fossils are found in the Hinton Formation and the flora correlates with the Namurian A Stage of Europe. *Stigmaria stellata* is a characteristic plant fossil found in this formation. Marine fossils are known from the limestone and calcareous shale deposits. These include rugose corals, bryozoans, brachiopods, pelecypods, gastropods, trilobites, crinoids, and a few fish fossils (Englund et al., 1979a; Miller, 1998). Brackish and freshwater assemblages also occur in the Hinton Formation (Henry and Gordon, 1979). Additionally, Hoare (1993) reports bivalve fauna from the Hinton and Bluestone formations of Virginia and West Virginia that include 49 different species from 29 genera. Miller (1998) reports rare occurrences of amphibian teeth up to 2cm in length from a basal conglomerate of the Hinton Formation. Beuthin and Blake (2004) have revised the stratigraphy and nomenclature for the Upper Hinton Formation and used general fossil content along with other characteristics to define the members. The fossils that were mentioned in this revision include ostracodes, lycopsid roots and stems, bivalve- dominated bioherms, corals, conularids, bryozoans, brachiopods, myalinid and pectinid bivalves, gastropods, cephalopods, trilobites, pelmatazoans (echinoderms), and burrows.

The Princeton Sandstone and the Bluestone Formation are mapped undivided within the boundaries of BLUE. These two Upper Mississippian formations consist of sandstone, shale, and siltstone. The Princeton Sandstone contains marine fauna, while the Bluestone Formation has produced marine, fresh, and brackish water fauna. The Bluestone Formation contains abundant ostracodes, pelecypods, and the brachiopod *Lingula* (Englund et al., 1979b). From the Bluestone Formation in Virginia and West Virginia, nonmarine ostracodes were researched by Sohn (1985). These ostracodes are of particular importance because they represent the oldest record in North America of particular adductor- muscle- attachment scar patterns. Henry and Gordon (1979) report on 21 different fossil invertebrate species from this formation. Miller (1998) reports in a Bluestone Formation shale member thin- valved bivalves, plant fragments, and imprints of shrimp- like arthropods. At a locality in Mercer County, West Virginia, a fossil lag deposit occurs at the contact between the Princeton and Bluestone formations and contains marine bivalves, brachiopods, and gastropods (Miller, 1998). Plant fossils are also known from these two geologic units and include *Lepidodendron veltheimi*, *Sphenopteris elegans*, and *Stigmaria stellata* (Gillespie and Pfefferkorn, 1979). Additionally *Sphenophyllum tenerrimum*, *Stigmata ficoldes*, *Cordaites* spp., *Calamites* spp., and *Asterophyllites longifollus* are also identified from the Bluestone Formation.

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DATA SETS:

DS- BLUE- XXX	Bluestone National Scenic River Paleontological Archives. 5/1985 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

DS- BLUE-XXX	Bluestone National Scenic River Files, Archive, Museum Records. 10/1988 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Bluestone National Scenic River; status: Active.

DELAWARE WATER GAP NATIONAL RECREATION AREA

Delaware Water Gap National Recreation Area (DEWA) was established in 1965 to preserve relatively unspoiled scenic and historic land along the uppermost section of the Delaware River that forms the political boundary between northwestern New Jersey and northeastern Pennsylvania. As the park name implies, the park preserves the segment of river that flows through the famous gap in the Appalachian Mountains.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

Delaware Water Gap National Recreation Area contains a rich Paleozoic fossil record and sparse, but under-explored Pleistocene (Ice Age) fossils. Over 1,300 paleontological specimens within DEWA s museum collection profile are held at the New Jersey State Museum, 90% of which have been identified and cataloged. There are plans to catalog these remaining specimens at the New Jersey State Museum when funding becomes available.

The Middle and Upper Ordovician Martinsburg Formation is the oldest fossiliferous unit exposed within DEWA. This thick unit (maximum thickness of 12,800 feet) is primarily composed of shales, sandstones, slates and greywacke siltstone (Epstein, 2001a; Parris and Cruikshank, 1984). There are reports of hundreds of specimens of shelly and graptolitic material recovered from the Martinsburg Formation at a number of sites in and around DEWA (Parris and Cruikshank, 1984, 1992; Parris et al., 1998a, 2001). Conulariid (*Conularia* cf. *trentonensis*), bryozoan (cf. *Prasopora* sp.), brachiopod (*Plectorthis plicatella*, *Dinorthis* sp., *Sowerbyella rugosa*, *Resserella multisecta*, *Dalmanella testudinaria*, and *Orbiculoidea* sp.), bivalve (*Prolobella corrugate*), nautiloid, gastropod (cf. *Sinuites* sp., cf. *Hormotoma* sp., and *Murchisonia* sp.), trilobite (cf. *Pterygometopus* sp. and *Cryptolithus tessellatus*), worms (*Cornulites* sp.), and crinoid (Crinoidea, indeterminate) specimens have been documented. Additionally, Beerbower (1956) reports on the occurrence of the trilobite *Triarthrus*, but unfortunately the locality is completely covered by construction (Parris and Cruikshank, 1984). From more than 20 localities within the Martinsburg Formation in the DEWA area, 26 graptolite genera have been identified including: *Adelograptus*, *Amplexograptus*, *Callograptus*, *Climacograptus*, *Clonograptus*, *Corynoides*, *Cryptograptus*, *Dicellograptus*, *Dicranograptus*, *Dictyonema*, *Didymograptus*, *Diplograptus*, *Glossograptus*, *Glyptograptus*, *Hallograptus*, *Isograptus*, *Lasiograptus*, *Nemagraptus*, *Orthograptus*, *Pseudisograptus*, *Pseudoclimacograptus*, *Pseudotrigonograptus*, ?*Reteograptus*, *Retiograptus*, *Tetragraptus*, and *Xiphograptus* (Parris and Cruikshank, 1992; Parris et al., 1998a, 2001). A specific report on brachiopod ecology of the Marstinsburg Formation was written by Bretsky and others (1969).

The Silurian Shawangunk Formation has a maximum thickness of 2,100 feet and primarily consists of coarse conglomerate, quartzose sandstone, and shale (Laughrey, 1999). The deposits represent fluvial and paralic environments (Laughrey, 1999). The Shawangunk Formation is sparsely fossiliferous and contains lingulid brachiopods, extinct arthropods (eurypterid remains including cf. *Hughmilleria shawangunk*), and rare Dipleurozoa (jellyfish- like fauna including *Rutgersella delawarensis*) (Parris and Cruikshank, 1984; Laughrey, 1999; Faul, 1990; Fox, 1968). Additionally, trace fossils are known from the Shawangunk Formation, including the feeding burrow *Arthrophycus alleghaniense* and vertical burrow *Skolithos* (Metz, 1997).

Overlying the Shawangunk Formation is the Silurian Bloomsburg Formation. This unit is composed of grayish- red claystone, siltstone, shale, sandstone, and conglomeratic sandstone. The formation is a time-transgressive unit (increasing young to the east) with deltaic sediments that have been deposited in saline waters supporting brackish- water fauna (Laughrey, 1999). Brachiopods and ostracodes are locally common while foraminifera, bryozoans, mollusks, and crinoids are rare (Laughrey, 1999). Fish scales of ostracoderms (*Vernonaspis* and *Americaspis*) occur locally in the Bloomsburg Formation (Epstein, 2001a; Monteverde, 2001a). Beerbower and Hait (1959) reported on two fish localities near DEWA that produced significant specimens of *Archegonaspis van ingeni*. Staff at the New Jersey State Museum relocated those sites and expanded the search for further fish evidence (Stein and Parris, 1979). This material awaits study and cataloging at the museum. Robert Denison (1964) investigated Silurian fish and was responsible for formalizing some of the taxonomy used for Silurian and Devonian Cyathaspididae. Hoskins (1960a, 1960b, 1961) reports specifically on the fossils found within the red beds of the Bloomsbrug Formation; citing foraminifera, ostracods, bryozoans, brachiopods, mollusks, crinoids, and fish scales. Metz (2000) reports the partial trace of an ancestral horseshoe crab that has rarely been documented.

The Silurian Bossardville Limestone consists of laminated argillaceous limestone and calcareous shale and averages 100 feet in thickness (Laughrey, 1999; Epstein, 2001a). The depositional environments can be categorized as supratidal, intertidal, and subtidal marine environments (Laughrey, 1999). Ostracodes are the dominant fossils in this formation and Leperditiidae specimens were found within DEWA (Parris and Albright, 1979a). Epstein and others (1967) also discuss the paleontology of the Bossardville Limestone.

The Silurian Decker Formation is composed of arenaceous and argillaceous limestone, calcareous sandstone and siltstone, and quartz- pebble conglomerate (Epstein, 2001a; Laughrey, 1999). The formation is approximately 100 feet thick and most likely represents a barrier beach and/or biostromal banks (Laughrey, 1999). This geologic unit is abundantly fossiliferous. Parris and Albright (1979a) report 9 coral, 4 bryozoan, 21 brachiopod, 3 gastropod, 1 nautiloid, 8 ostracod, 5 trilobite, 3 worm , and 1 crinoid species from the Decker Formation. Between 1996 and 2003, Metz conducted many investigations regarding trace fossils of the Decker Formation. The ichnogenera *Cruziana* isp., *Diplichnites* isp., *Lockeia siliquaria*, *Palaeophycus heberti*, *Planolites beverleyensis*, *Protovirgularia rugosa*, and *Skolithos* sp. have been identified and the likely producers of these trackways are arthropods, mollusks, and worm- like forms. In addition to the trace fossils, Metz also reports corals, bryozoans, brachiopods, and crinoid debris from the Decker Formation.

The Upper Silurian and Lower Devonian Rondout Formation is approximately 30 feet thick and is composed of calcareous shale, argillaceous limestone, biostromal limestone, and laminated dolomite (Epstein, 2001a). Fauna from this formation within DEWA include 6 coral, 2 bryozoan, 3 brachiopod, 1 clam, 4 ostracod, and 1 crinoid species (Parris and Albright, 1979a; Herper, 1951a).

The Lower Devonian Coeymans Formation consists of many members, including beds of the previously named Manlius Limestone. The Coeymans Formation primarily consists of arenaceous, argillaceous, and biogenic limestone and preserves a nearshore environment (Epstein, 2001a; Laughrey, 1999). Epstein (2001b) recounts the occurrence of conodonts from the Coeymans Formation. Parris and Albright (1979a) report 6 coral, 4 bryozoan, 30 brachiopod, 6 clam, 3 gastropod, 1 nautiloid, 6 ostracod, 3 trilobite, 1 crinoid, and 2 worm species from this unit within DEWA. According to National Park Service Investigator Annual Reporting between 1996 and 2003, Metz reports the occurrence of crinoid columnals and the trace fossils *Skolithos linearis*, *S. verticalis*, *S. pusillus*?, *Chondrites affinis*, *C.* isp., *Palaeophycus tubularis*, and *Planolites beverleyensis* from the Coeymans Formation. There are fossil- rich patch reefs and reef flanks in the Coeymans Formation that contain bioclastic debris of tabulate corals (*Cladopora* and *Favosites*), rugose corals, stromatoporoids, brachiopods, and crinoids (Monteverde, 2001b; Metz, 2003).

The Lower Devonian New Scotland Formation is approximately 70 feet thick and is composed of dark- gray silty calcareous shale with lenticular argillaceous limestone (Epstein, 2001a). Both the shale and the limestone are known to contain fossils. Sponges (*Hindia fibrosa*), corals (*Enterolasma strictum*), bryozoans, brachiopods (28 species), clams (3 species), gastropods (2 species), nautiloids (Michelinoceratidae), trilobites (2 species), crinoids (*Icthyocrinus magnaradialis*), and worms (*Tentaculites elongates*) have been discovered from the New Scotland Formation within DEWA (Parris and Albright, 1979a).

The Lower Devonian Minisink Limestone is a dark- to medium- gray argillaceous limestone (Epstein, 2001a). Although the thickness is less than 15 feet, fossils have been found from this geologic unit. The fauna resembles that of the New Scotland Formation and consists of corals, bryozoans, brachiopods, clams, gastropods, ostracods, trilobites, and crinoids (Parris and Albright, 1979a).

The Lower Devonian Port Ewen Shale is 150 feet thick and is a laminated calcareous shale and siltstone (Epstein, 2001a). Parris and Albright (1979a) report 11 brachiopod species, ostracods, 3 trilobite species, and crinoids from the Port Ewen Shale within DEWA. Additionally, Albright (1995) reports a single specimen of conulariid, *Conularia pyramidalis*, from a site that has since been destroyed. This report also includes other specimens occurring in DEWA from younger strata.

The Lower Devonian Oriskany Group is composed of multiple geologic units; Shriver Chert, Ridgeley Formation, and Glenerie Formation (Ver Straeten et al., 1995). The Shriver Chert is 50-85 feet thick and composed of shale, siltstone, pods of dark-gray chert, and minor calcareous sandstone (Epstein, 2001a). The Ridgeley Sandstone, with a maximum thickness of 16 feet, is a fine- to coarse-grained calcareous sandstone with lesser amounts of siltstone, arenaceous limestone, and chert (Epstein, 2001a). Parris and Albright (1979a) refer to collections discovered from the Oriskany Formation within DEWA. Further research has indicated that these collections come from the Glenerie Formation (northernmost sections of DEWA) and the Ridgeley Formation (southern sections of DEWA) (S. Albright, personal communication, 2004). These collections include 3 coral, 1 bryozoan, 41 brachiopod, 5 gastropod, 1 nautiloid, 3 worms , 2 ostracod, 3 trilobite, and 1 crinoid species. Specifically from the Ridgeley Sandstone, Metz (2002) reported *Planolites* trace fossils that indicates a beach or barrier beach deposition. Ver Straeten (2001a) reports large, robust brachiopods (*Costispirifer*, *Rensselaeria*, and *Hipparionyx*) from the Oriskany Sandstone . Ostracodes from Sussex County, New Jersey, including Oriskany Formation specimens, were the topic of a Master s Thesis by Horton (1950).

The Lower Devonian Esopus Formation has a maximum thickness of 300 feet and consists of shale and arenaceous siltstone (Epstein, 2001a). *Taonurus* burrows are common in this geologic unit (Epstein, 1984; 2001a). Metz (1996-2003) collected *Taonurus* and *Skolithos* trace fossils from the Esopus Formation. Additionally, *Zoophycos* and *Chondrites* ichnofossils are also present (Ver Straeten, 2001a). Corals, conularids, brachiopods, gastropods, cephalopods, arthropods, and crinoids have been discovered from the Esopus Formation within DEWA (Parris and Albright, 1979b). The type specimen of *Reticulaconularia sussexensis* (conulariid) was discovered in the Esopus Formation and described by Henry Herpers (1949). Investigations by Babcock and Feldman (1986a, 1986b) resulted in the complete taxonomic revision of these rare, problematic organisms.

The Lower Devonian Schoharie Formation is 100 to 150 feet thick and is primarily composed of argillaceous calcareous siltstone (Epstein, 2001a). Corals, brachiopods, gastropods, cephalopods, and trilobites are noted from DEWA (Parris and Albright, 1979b; Ver Straeten, 2001b). Trace fossils of *Zoophycos* and *Chondrites* are also common in the Schoharie Formation (Ver Straeten, 2001a).

The Middle Devonian Buttermilk Falls Limestone is predominately composed of a fossiliferous gray limestone. Parris and Albright (1979b) report 3 coral, 1 bryozoan, 23 brachiopod, 2 cephalopod, and 6 trilobite species from DEWA. Epstein (1984) reports crinoid columnals in the Buttermilk Falls Limestone. *Helminthopsis* trace fossils that were deposited in subtidal waters have been found in this unit (Metz, 2002).

The Middle Devonian Marcellus Formation has a maximum thickness of 1,150 feet and consists of silty shale, laminated shale, and shaly limestone, (Epstein, 2001a). Paleontological sites are rare within the Marcellus Formation and occur in fine-grained, black shale containing diminutive fauna typical of under-oxygenated, deep marine waters (S. Albright, personal communication, 2004). Indeterminate plant material, an indeterminate conulariid, indeterminate bryozoans, 15 brachiopod species, 10 bivalves, 1 worm (*Styliolina fissurella*), 2 cephalopod species, 2 trilobite species, and an additional arthropod (*Onychodus sigmoides*?) were all discovered in the Marcellus Formation within DEWA (Parris and Albright, 1979b). Storm (1985) studied fauna from the Marcellus Formation for a Master s Thesis that included sites from Sussex County, New Jersey.

The Middle Devonian Mahantango Formation has a maximum thickness of over 2,000 feet and is composed of siltstone and silty-shale (Epstein, 2001a). This formation has produced plant fragments, algae (*Receptaculites*? sp.), corals, conularids, bryozoans, brachiopods, bivalves, gastropods, cephalopods, trilobites, additional arthropods, worms , crinoid columnals, fish, and burrows (Parris and Albright, 1979b). Within DEWA, Parris and Albright (1979b) report that the Mahantango Formation is very well-known for its fossils and contains plant impressions and carbonized fragments, 4 coral species, 3 bryozoan species, 12 brachiopod species, 6 bivalve species, 3 trilobite species, crinoid columnals, and trace fossils (burrows, tracks, and trails). In 1971, El- Ashry reported on the discovery of a new coral reef named Barton s reef that represents a stable shelf environment with rugose and tabulate corals. A faunally rich area from the Mahantango Formation termed the Centerfield Fossil Zone/Horizon is located within Monroe County (Beerbower, 1957; Wilt, 2001). Cramer (1959) describes a starfish (*Hudsonaster wardi*) found near Milford, Pennsylvania that expanded the age range for the genus. Colonial coral populations from the Mahantango Formation of Monroe County, Pennsylvania were the emphasis of study for Wolosz and Wallace (1981). Conularids from the Mahantango Formation were reported by Babcock (1985) and Kasznica (1986).

The Upper Devonian Trimmers Rock Formation is 720- 1,825 feet in thickness and consists of siltstone, shale, and very fine- grained sandstone (Epstein, 2001a). Fauna from the Trimmers Rock Formation is diverse due to the wide age and geographical range. A broad variety of plants, corals, bryozoans, brachiopods, bivalves, gastropods, worms , trilobites, additional arthropods, crinoids, and fish specimens have been recovered from this formation (Parris and Albright, 1979b). Inners (1981) studied the invertebrate fauna from beds within the Trimmers Rock Formation in Columbia County, Pennsylvania.

Pleistocene deposits are found within the boundaries of DEWA and have potential to produce paleontological resources. Fossils have been discovered from several localities neighboring the park. Many mastodons have been recovered including a mastodon from Marshall s Creek that was discovered in bog muds (Hoff, 1969). The most complete specimen of a *Cervalces scotti* (elk- moose) was found in Warren County, New Jersey and an additional specimen was found just outside DEWA along with freshwater mollusks (Parris and Albright, 1979a). Hartman Cave (or Crystal Hill Cave) in Monroe County, Pennsylvania has produced a wealth of vertebrate material. This cave contains material from a probable date range of the Pleistocene, Colonial, and Recent periods (Parris and Albright, 1979a). Hay (1923) reports the following species list from Hartman Cave: *Chelydra serpentine* (common snapping turtle), *Terrapene carolina* (eastern box turtle), *Meleagris gallopavo* (turkey), *Rangifer caribou* (caribou), *Odocoileus virginianus* (white- tailed deer), *Mylohyus pennsylvanicus* (extinct peccary), *Equus* sp. (horse), *Cervus canadensis* (elk), *Bison bison* (questionable bison identification), *Marmota monax* (woodchuck), *Tamias striatus* (eastern chipmunk), *Sciurus carolinensis* (eastern gray squirrel), *Castor canadensis* (beaver), *Peromyscus leucopus* (white- footed mouse), *Neotoma floridana* (eastern woodrat), *Microtus pennsylvanicus* (meadow vole), *Erethizon dorsatum* (porcupine), *Castoroides ohioensis* (extinct giant beaver), *Sylvilagus floridanus* (eastern cottontail), *Myotis subulatus* (small- footed myotis), *Eptesicus fuscus* (big brown bat), *Scalopus aquaticus* (eastern mole), *Procyon lotor* (raccoon), *Mustela erminea* (short- tailed weasel), *Mephitis mephitis* (striped skunk), *Urocyon cinereoargenteus* (gray fox), *Canis lupus* (questionable gray wolf identification), and *Lynx canadensis* (Canada lynx).

COOPERATIVE PROJECTS:

- Ordovician Faunas in the Delaware Water Gap region David Parris, New Jersey State Museum (1984- 2000).
- Lower and Middle Paleozoic Paleontology of the Delaware Water Gap National Recreation Area and Vicinity Shirley Albright, New Jersey State Museum (1991- 1998).
- Geology of Delaware Water Gap National Recreation Area Jack Epstein, U.S. Geological Survey (1996- 1999).
- Ichnologic investigation of Paleozoic rocks in northern New Jersey (Delaware Water Gap National Recreation Area) Robert Metz, Kean University (1996- 2003).
- Geologic and Paleontologic Scoping of Delaware Water Gap National Recreation Area National Park Service Geologic Resources Division (October 2001).

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DATA SETS:

DS-DEWA-XXX	Delaware Water Gap National Recreation Area Paleontological Archives. 5/1985 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.
DS-DEWA-XXX	Delaware Water Gap National Recreation Area Files, Archive, Museum Records. 9/1965 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Delaware Water Gap National Recreation Area; status: Active.

DS- DEWA-XXX	New Jersey State Museum Paleontological Records. 1984 present. (hard copy data; field notes; reports; photographs; maps; collections; publications). Originated by New Jersey State Museum (David Parris and Shirley Albright); status: Active.
DS- DEWA-XXX	Geology of Delaware Water Gap region. 1900s present. (hard copy data; field notes; reports; photographs; maps; collections; publications). Originated by U.S. Geological Survey (Jack Epstein); status: Active.
DS- DEWA-XXX	Ichnofossil investigations in the Delaware Water Gap region. 1996- present. (hard copy data; field notes; reports; photographs; maps; collections; publications). Originated by Robert Metz; status: Active.
DS- DEWA-XXX	Geologic Inventory of Delaware Water Gap National Recreation Area. 2001- present. (hard copy data; reports; maps; publications). Originated by the Geologic Resources Division of the National Park Service (Tim Connors); status: Active.

FORT NECESSITY NATIONAL BATTLEFIELD

Fort Necessity National Battlefield (FONE) was established as a national battlefield in March 1931. The opening battle of the French and Indian War was fought at this site where colonial troops, commanded by the 22- year- old Col. George Washington, were defeated on July 3, 1754.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

Fort Necessity National Battlefield protects three separate units of property: Fort Necessity, Braddock s Grave, and Jumonville Glen. Fort Necessity and Braddock s Grave share similar geology, while Jumonville Glen preserves slightly older deposits. Although the geologic units that occur within the park are known to contain fossils, no fossils have been formally recorded from within the boundaries of FONE.

The oldest geologic unit exposed in the park is the Mississippian Burgoon Sandstone and can be found in Jumonville Glen. The Burgoon Sandstone is primarily a non- marine, fluvial sandstone (T. Kammer, written communication, 2004). This formation also consists of conglomerate, shale, and coal. Trace fossils have been discovered in this formation in central- western Pennsylvania and plant fossils are noted from northern, western, and central Pennsylvania (Berg et al., 1980).

The other unit exposed in FONE is the Pennsylvanian Glenshaw Formation found in the Fort Necessity and Braddock s Grave areas. This formation is composed of shale, sandstone, limestone, and coal. The Glenshaw Formation is known to be very fossiliferous in many areas of Pennsylvania, Ohio, and West Virginia, most notably in the Brush Creek, Pine Creek, and Ames marine zones. In southwestern Pennsylvania, Roen and others (1968) report that the limestone and calcareous shale contain marine fossils. Biogenic mounds containing abundant vertical burrows, presumably from malacostracan crustaceans, are known from southwestern Pennsylvania and eastern Ohio exposures of the Glenshaw Formation (Carothers and Norton, 1975). Crinoid and trilobite fossils from the Glenshaw Formation were used for investigations of mineralogy and fluorescence of skeletal carbonates by Durika and others (1987). Foraminifera have also been studied from the Glenshaw Formation. Palaeotextulariid foraminifera and endothyroid foraminifera were reported on from the Appalachian basin (Moira et al., 1988; Hoare and Sturgeon, 1998). From a quarry in eastern Ohio, Rollins and others (1979) report are variety of fauna from the Glenshaw Formation including, fusulinids, bryozoans, brachiopods, crinoids and fish fragments. Lepold (2003) reports corals, brachiopods, bivalves, and crinoids from the Glenshaw Formation in eastern Ohio. Conodonts were examined at Ebensburg, Pennsylvania to identify the marine unit as part of the Ames (Merrill, 1988). Additional fauna at the site include foraminifera, brachiopods, bivalves, gastropods, cephalopods, echinoderms, and shark s teeth (Brady et al., 1985). An additional locality in Beaver County of the Ames marine zone produced over 30 species of invertebrates, vertebrates, and trace fossils (Harper, 1986). Finally, conodonts from the Ames and Brush Creek marine zones were used for testing the validity of using uranium, thorium, and lead contents for dating (Kovach and Zartman, 1981).

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FRIENDSHIP HILL NATIONAL HISTORIC SITE

Friendship Hill National Historic Site (FRHI) was established in 1978 to preserve Albert Gallatin s home along the Monongahela River. This Swiss emigrant is best known for serving as Secretary of the Treasury during Jefferson and Madison s administrations. Gallatin s accomplishments and contributions during the turn of the 19th century to the American Republic are interpreted at the restored Friendship Hill house.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

Two Pennsylvanian- age geologic units are found within FRHI. Although these geologic units are known to contain fossils, no fossils have been formally recorded from within the boundaries of FRHI.

The oldest geologic unit in FRHI is the Upper Pennsylvanian Casselman Formation. This formation is primarily composed of shale, siltstone, sandstone, limestone, and coal. The lowest portion of the formation contains a marine zone, which is composed of a fossiliferous shale (Edmunds et al., 1999). Additionally, nonmarine bivalve fossils have been reported from the Casselman Formation by Eager (1975). Vertebrate fauna discoveries were made by Raymond (1911) and more recently by Lund (1975). One of the more interesting fossil findings in the Casselman Formation is reported on by Marks and others (1998). A pair of problematic tracks were found in Cambria County. Due to comparison with an analogous trackway found in similary- aged rocks in Scotland, the authors presume that the trackway was caused by a giant myriapod (6- foot long millipede- type invertebrate).

The other geologic unit found within FRHI is the Upper Pennsylvanian Monongahela Group. This group consists of limestone, shale, sandstone, and coal. Eager (1975) comments on the nonmarine bivalves and Lund (1975) provides descriptions of the fossil vertebrates found in the Monongahela Group within the state of Pennsylvania. In southeastern Ohio, Bain (1992) reports on stromatolites from the Monongahela Group that vary in size from masses that are 30 cm in diameter to continuous beds.

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DS- FRHI- XXX Friendship Hill National Historic Site Files, Archive, Museum Records. 11/1978 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Friendship Hill National Historic Site; status: Active.

GAULEY RIVER NATIONAL RECREATION AREA

Gauley River National Recreation Area (GARI) was established in 1988 and preserves 25 miles of the Gauley River and 6 miles of the Meadow River. Scenic gorges and valleys contain a variety of natural and cultural features. Most noteworthy are the exciting whitewater opportunities provided by the several Class V+ rapids of the Gauley River.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The majority of GARI is placed within the Lower Pennsylvanian New River Formation. The perimeter of the park boundary also crosses into smaller sections of the Middle Pennsylvanian Kanawha Formation. Many of the publications do not specify precise locality information nor do they reference GARI boundaries. Although many fossils are known from these formations in the area, it is unclear if paleontological resources have been formally documented within the park s boundary.

The New River Formation is the oldest geologic unit found within GARI. This formation is primarily composed of coal- bearing sandstones, siltstones, and shale. Many fossil plants have been identified from the New River Formation. Gillespie and Pfefferkorn (1978) reported on many species of plant fossils, including 6 lycopods, 8 sphenopsids, 7 pteridosperms, and 1 cordaite. Four species of the genus *Neuralethopteris*, a pteridosperm, were discovered from the New River Formation (Goubet et al., 2000). The New River Formation contains fresh- or brackish- water invertebrates and additional fossil plants, including some that differ across the New River and Kanawha Formation boundary (Englund et al., 1986; Arndt et al., 1979a). Henry and Gordon (1979) list several fossil invertebrates from the New River Formation: rugose coral, brachiopods (*Lingula carbonaria*, *Orbiculoidea* sp., small marginiferid productid?, and *Composita* sp.), pelecypods (*Nuculopsis* cf. *girtyi*, *Phestia* sp., *Paleyoldia*(?) sp., *Schizodus*(?) sp., and *Palaeosolen* sp.), gastropods (bellerophontacean, *Straparollus* (*Euomphalus*?) sp., and pleurotomariacean), and echinoderms (pelmatozoan columnals). Remains of a fossil fish named for its sculptured fins (*Gyracanthus* sp.) were also found from within the Beckley coal zone from the New River Formation (Lund et al., 1979).

The other geologic unit exposed within the park is the Middle Pennsylvanian Kanawha Formation, which consists of shale and siltstone, as well as smaller amounts of sandstone. Martino (1991) identified 10 marine zones within the Kanawha Formation that contain shells, plant impressions (*Calamites*), and trace fossils (*Olivellites* burrows). Previous work by Martino (1989) on trace fossils identified 7 ichnogenera from the Kanawha Formation of West Virginia, and included investigations of arthropod dwellings and other burrows. Within the Kanawha Formation, Gillespie and others (1978) report on fossil plant species; 6 lycopods, 9 sphenopsids, 4 pteridosperms, and 1 cordaite. Englund and others (1986) report that the Kanawha Formation contains root penetrations, abundant plant impressions, marine brachiopods, brackish-water and marine pelecypods, marine gastropods, and burrows. Henry and Gordon (1979) summarize the invertebrate fauna and list over 80 species discovered from 7 localities within the Kanawha Formation. Arndt and others (1979a, 1979b) also report on multiple occurrences of plant, invertebrate, and trace fossil material from field trip logs through Fayette County, West Virginia. Vertebrate material including fish teeth and scales have been discovered from the Kanawha Formation in Fayette County (Arndt et al., 1979a). Lund and others (1979) list the identified fish material: *Sphaerolepis* sp., *Ectosterohachius* sp., *Sagenodus* sp., *Xenacanthus* sp., *X. triodes*, *Orthacanthus* sp., *O.* cf. *compressus*, *Hybodus* sp., *Helodus simplex*, *Haplolepis* sp.

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JOHNSTOWN FLOOD NATIONAL MEMORIAL

Johnstown Flood National Memorial (JOFL) was preserved in 1964 to memorialize the devastating flood of 1889 that was caused by a break in the South Fork Dam. The Johnstown Flood resulted in the deaths of 2,209 people, representing the deadliest flood in American history. Additionally, Clara Barton led the first successful Red Cross disaster relief effort.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

Two Pennsylvanian- age geologic units are found within JOFL. Although these geologic units are known to contain fossils, no fossils have been formally recorded from within the boundaries of JOFL.

The oldest geologic unit exposed in JOFL is the Pennsylvanian Glenshaw Formation. This formation is composed of shale, sandstone, limestone, and coal. The Glenshaw Formation is known to be very fossiliferous in many areas of Pennsylvania, Ohio, and West Virginia, most notably in the Brush Creek, Pine Creek, and Ames marine zones. In southwestern Pennsylvania, Roen and others (1968) report that the limestone and calcareous shale contain marine fossils. Biogenic mounds containing abundant vertical burrows, presumably from malacostracan crustaceans, are known from southwestern Pennsylvania and eastern Ohio exposures of the Glenshaw Formation (Carothers and Norton, 1975). Crinoid and trilobite fossils from the Glenshaw Formation were used for investigations of mineralogy and fluorescence of skeletal carbonates by Durika and others (1987). Palaeotextulariid foraminifera and endothyroid foraminifera were reported from the Appalachian basin (Moira et al., 1988; Hoare and Sturgeon, 1998). From a quarry in eastern Ohio, Rollins and others (1979) report a variety of fauna from the Glenshaw Formation including fusulinids, bryozoans, brachiopods, crinoids, and fish fragments. Also from eastern Ohio, Lepold (2003) reports brachiopods, crinoids, bivalves, and corals from the Glenshaw Formation. Conodonts were examined at Ebensburg, Pennsylvania and were utilized to identify the marine unit as part of the Ames (Merrill, 1988). Additional fauna at the site include foraminifera, brachiopods, bivalves, gastropods, cephalopods, echinoderms, and shark s teeth (Brady et al., 1985). An additional locality within the Ames marine zone in Beaver County produced over 30 species of invertebrates, vertebrates, and trace fossils (Harper, 1986). Lastly, conodonts from the Ames and Brush Creek marine zones were used for testing the validity of using uranium, thorium, and lead contents for dating (Kovach and Zartman, 1981).

The other geologic unit in JOFL is the Casselman Formation. This formation is primarily composed of shale, siltstone, sandstone, limestone, and coal. The lowest portion of the formation contains a marine zone, which is composed of a fossiliferous shale (Edmunds et al., 1999). Additionally, nonmarine bivalve fossils have been reported by Eager (1975). Vertebrate fauna discoveries were made by Raymond (1911) and more recently by Lund (1975). One of the more interesting fossil findings in the Casselman Formation is reported on by Marks and others (1998). A pair of problematic tracks were found in central Cambria County, north of JOFL. Due to comparison with an analogous trackway found in similary- aged rocks in Scotland, the authors presume that the trackway was caused by a giant myriapod (6- foot long millipede- type invertebrate).

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NEW RIVER GORGE NATIONAL RIVER

New River Gorge National River (NERI) was preserved in 1978 to protect a 53- mile section of the New River from Hinton to Fayetteville, West Virginia. Contrary to its name, the New River is among the oldest rivers on the continent and flows northward cutting through the Ridge and Valley province of the Appalachian Mountains and then cutting a deep gorge in the Appalachian Plateau.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The Upper Mississippian Bluefield Formation is found in a small exposure in the southern portion of the park. The Bluefield Formation consists mostly of marine calcareous shale with smaller beds of limestone, sandstone, and siltstone. These deposits reflect a shallow- water marine environment (Englund et al., 1979). Henry and Gordon (1979) report 5 marine faunal assemblages within the Bluefield Formation and that the lower section of the formation is particularly fossiliferous. Plant megafossils have been collected from the upper portion of the Bluefield Formation (Gillespie and Pfefferkorn, 1979). *Stigmaria ficoides*, *Cyperites bicarinatus*, *Lepidostrobophyllum* spp., *Calamites radiatus*, *Mesocalamites* sp., *Sphenopteris elegans*, and *Cordaites* sp. have been identified from this formation (Gillespie and Pfefferkorn, 1984a). Additionally, Kammer and others (1987) discuss assigning the problematic edrioasteroid (extinct echinoderms) *Hemicystites*? *carbonarius* specimen from the Bluefield Formation to the new edrioasteroid genus, *Neoisorophusella*.

The Upper Mississippian Hinton Formation is also exposed within the boundaries of NERI. This formation is composed of sandstone, shale, siltstone, limestone, and coal and represents the interrelationship of marine and terrestrial sediments. Englund and others (1979) report that plant fossils are found in the Hinton Formation and the flora correlates with the Namurian A Stage of Europe. *Stigmaria stellata* is a characteristic plant fossil found in this formation. Marine fossils are known from the limestone and calcareous shale deposits. These include rugose corals, bryozoans, brachiopods, pelecypods, gastropods, trilobites, crinoids, and a few fish fossils (Englund et al., 1979a; Miller, 1998). Brackish and freshwater assemblages also occur in the Hinton Formation (Henry and Gordon, 1979). Additionally, Hoare (1993) reports bivalve fauna from the Hinton and Bluestone formations of Virginia and West Virginia that include 49 different species from 29 genera. Miller (1998) reports rare occurrences of amphibian teeth up to 2cm in length from a basal conglomerate of the Hinton Formation. Beuthin and Blake (2004) have revised the stratigraphy and nomenclature for the Upper Hinton Formation and used general fossil content, along with other characteristics, to define the members. The fossils that were mentioned in this revision include ostracodes, lycopsid roots and stems, bivalve- dominated bioherms, corals, conularids, myalinid and pectinid bivalves, bryozoans, brachiopods, gastropods, cephalopods, trilobites, pelmatazoans (echinoderms), and burrows.

The Upper Mississippian Bluestone Formation is found within NERI and consists of sandstone, shale, and siltstone. The Bluestone Formation contains abundant ostracodes, pelecypods, and the brachiopod *Lingula* (Englund and others, 1979b). Nonmarine ostracodes within the Bluestone Formation from Virginia and West Virginia were researched by Sohn (1985). These ostracodes are of particular importance because they represent the oldest record in North America of particular adductor- muscle- attachment scar patterns. Henry and Gordon (1979) report on 21 different fossil invertebrate species from this formation. Miller (1998) reports plant fragments, thin- valved bivalves, and imprints of shrimp- like arthropods in a Bluestone Formation shale member. Plant fossils are also known from the Bluestone Formation including *Lepidodendron veltheimi*, *Sphenopteris elegans*, *Stigmaria stellata*, *Sphenophyllum tenerrimum*, *Stigmata ficoldes*, *Cordaites* spp., *Calamites* spp., and *Asterophyllites longifollus* (Gillespie and Pfefferkorn, 1979).

The Lower Pennsylvanian Pocahontas Formation is primarily composed of coal- bearing sandstone with lesser amounts of siltstone and shale. Ostracod molds and sparse *Lingula* have been noted from this geologic unit (Englund et al., 1986). Henry and Gordon (1979) state that the Pocahontas Formation contains freshwater molluscan assemblages and are generally *Naiadites*- dominated. A greater wealth of information has been produced for the fossil plants of the Pocahontas Formation. Goubet and others (2000) focused their investigations on the biostratigraphy, phylogeny, paleoclimatology, and paleoecology of the plant genus *Neuralethopteris* based on many specimens collected from West Virginia and Virginia. Englund and others (1986) comment on the occurrences of *Neuropteris pocahontas*, *Lepidodendron dichotomum*, *Lyginopteris hoeninghausii*, *Sphenopteris pottsvillea*, *Sphenopteris preslesensis*, *Mesocalamites eremopteroides*, *Alethopteris evansi*, *Alethopteris davreuxi*, and *Aneimites pottsvillensis*. This report also denotes that *Neuropteris pocahontas*, a marker fossil that helps to delineate the bottom of the Pennsylvanian system, is profuse with well-preserved fronds, pinnules, male reproductive bodies (*Aulacotheca campbelli*), and seeds (*Holcospermum maizeretense*). Gillespie and Pfefferkorn (1979, 1984a) also report on additional plant species found within the Pocahontas Formation: *Neuropteris smithsii*, *Palmatopteris furcata*, *Lepidodendron aculeatum*, *Lepidodendron obovatum*, *Stigmaria ficoides*, *Cyperites bicarinatus*, *Lepidostrobophyllum* spp., *Calamites radiatus*, *Mesocalamites cistii*, *Mesocalamites suckowii*, *Asterophyllites longifolius*, *Calamostachys* sp., *Mariopteris pottsvillea*, *Trigonocarpus* sp., and *Cordaites* sp.

The New River Formation is a Lower Pennsylvanian unit found within NERI. This formation is primarily composed of coal-bearing sandstones, siltstones, and shale. Many fossil plants have been identified from the New River Formation. Gillespie and others (1978) reported on many species of plant fossils, including 6 lycopods, 8 sphenopsids, 7 pteridosperms, and 1 cordaite. Four species of the genus *Neuralethopteris*, a pteridosperm, were discovered from the New River Formation (Goubet et al., 2000). The New River Formation contains fresh- or brackish-water invertebrates and additional fossil plants, including some that differ across the New River and Kanawha Formation boundary (Englund et al., 1986; Arndt et al., 1979a). Henry and Gordon (1979) list several fossil invertebrates from the New River Formation: rugose coral, pelmatozoan columnals, *Lingula carbonaria*, *Orbiculoidea* sp., small marginiferid productid?, *Composita* sp., *Nuculopsis* cf. *girtyi*, *Phestia* sp., small pelecypods, *Paleyoldia*(?) sp., *Schizodus*(?) sp., bellerophontacean, *Straparollus* (*Euomphalus*?) sp., pleurotomariacean, and *Palaeosolen* sp. Remains of a fossil fish named for its sculptured fins (*Gyracanthus* sp.) were also found from the Beckley coal zone from the New River Formation (Lund et al., 1979).

COOPERATIVE PROJECTS:

- Proposal for Paleontological Survey of the New River Gorge National River Mitchel Blake, West Virginia Geological and Economic Survey (not yet funded).

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DATA SETS:

DS- NERI- XXX	New River Gorge National River Paleontological Archives. 5/1985 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.
DS- NERI- XXX	New River Gorge National River Files, Archive, Museum Records. 11/1978 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by New River Gorge National River; status: Active.

UPPER DELAWARE SCENIC AND RECREATIONAL RIVER

Upper Delaware Scenic and Recreational River (UPDE) was established in 1968 and preserves a 63-mile stretch of the river. Additionally, the park contains the Roebling Bridge, possibly the oldest existing wire-cable suspension bridge, and the Zane Grey home and museum.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

Although there are 55,575 acres within the Upper Delaware River corridor, only 31 acres are owned by the National Park Service. However, good exposures of sedimentary rock occur in the park-owned land (D. Hamilton, personal communication, 2004). Although no fossils have been formally recorded within the boundaries of UPDE, the geologic unit that occurs within the park is known to contain paleontological resources in other areas of Pennsylvania and New York.

The only geologic unit exposed in UPDE is the Devonian Catskill Formation. The formation primarily consists of sandstone, siltstone, shale, conglomerate, and mudstone. The Catskill Formation contains both marine and nonmarine fossils (Berg et al., 1980; Harper, 1999). The Academy of Natural Sciences in Philadelphia is currently working on what they refer to as the Catskill Project . Through this research, plants, plant spores, invertebrates, and all major classes of vertebrates have been discovered. Additionally, they have discovered and described two new taxa of limbed vertebrates from the Catskill Formation; *Densignathus rowei* and *Hynerpeton bassetti*. These significant tetrapod discoveries from Clinton County, Pennsylvania have extended the temporal range of North American tetrapods and shed light on morphological evolution (Daeschler et al., 1994). Ted Daeschler, Assistant Curator at the Academy of Natural Sciences in Philadelphia (personal communication, 2004), indicates that in the UPDE region, the Catskill Formation is more likely coarser than the areas they have previously investigated, and the depositional environment is less likely to support much life, especially vertebrate preservation. However, there is greater potential to find nearshore marine invertebrate fossils.

Additionally, the State Museum of Pennsylvania houses many fish specimens and the University of California Museum at Berkeley houses 1 plant and 4 vertebrate specimens from the Catskill Formation. Specific paleobotanical research was conducted by Scheckler and Banks (1971) and Brauer (1980a). Scheckler and Banks investigated a new genus of progymnosperms and suggest some evolutionary trends among the Aneurophytales. Brauer discusses interesting features of a *Barinophton citrulliforme* and suggests various interpretations. Fossil pollen analyses were conducted from Catskill Formation material in order to help date rocks and differentiate sedimentary units (Traverse, 1974; Wilson and Traverse, 1975). Walter (2001) researched evidence for the earliest known wildfire from a charcoal deposit in the Catskill Formation.

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Data Sets:

DS- UPDE-XXX	Upper Delaware Scenic and Recreational River Paleontological Archives. 5/1985 present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.
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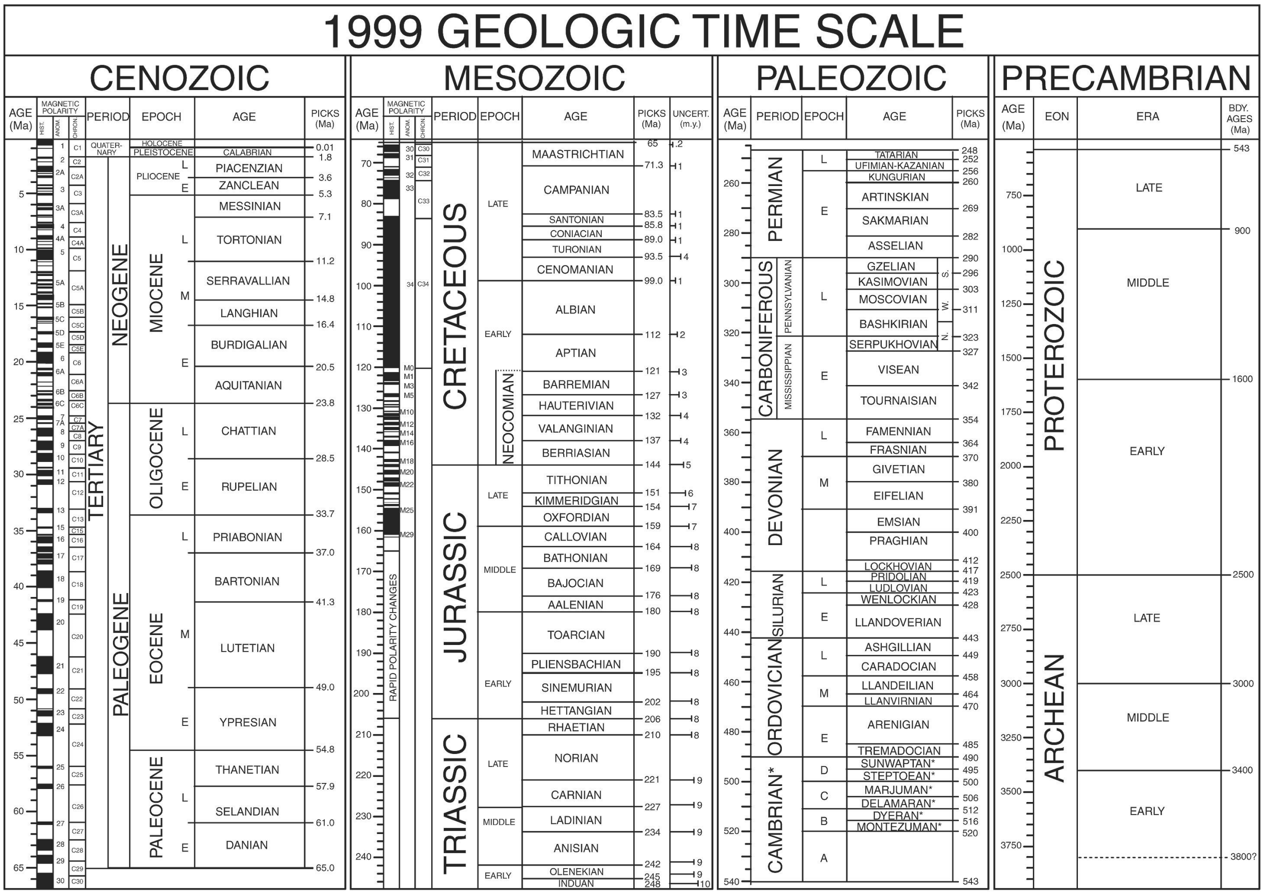
APPENDIX A: GEOLOGIC TIME SCALE



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*International ages have not been established. These are regional (Laurentian) only. Boundary Picks were based on dating techniques and fossil records as of 1999. Paleomagnetic attributions have errors, Please ignore the paleomagnetic scale.

Sources for nomenclature and ages: Primarily from Gradstein, F., and Ogg, J., 1996, *Episodes*, v. 19, nos. 1 & 2; Gradstein, F., et al., 1995, SEPM Special Pub. 54, p. 95–128; Berggren, W. A., et al., 1995, SEPM Special Pub. 54, p. 129–212; Cambrian and basal Ordovician ages adapted from Landing, E., 1998, *Canadian Journal of Earth Sciences*, v. 35, p. 329–338; and Davidek, K., et al., 1998, *Geological Magazine*, v. 135, p. 305–309. Cambrian age names from Palmer, A. R., 1998, *Canadian Journal of Earth Sciences*, v. 35, p. 323–328.

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Note: Picks (Ma) = age of the geologic time unit boundary in millions of years (Ma).

This timescale is available online as a PDF: http://www.geosociety.org/science/timescale/timescl.pdf